

ATR from medium resolution images for all weather terminal guidance

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SUMMARY

In the context of air to ground terminal guidance applications, the main purpose of ATR is to refine the target position. This paper presents a feature based ATR technique. A first evaluation on the MIMEX data, with ground truth, shows good results. An analysis of the results relative to image quality is presented on the MATRIX 2005 data (FGAN Ka images, no ground truth).

1. INTRODUCTION

In the context of air to ground guidance applications, the main purpose of ATR is to refine the position of the target. The main task is thus to detect with minimum false alarms the nominal target. Localization errors could be due to designation errors and target displacement between mission planning and attack. Classification of all potential targets is only a second goal.

Targets are supposed fixed at imaging time. The air to ground context leads to specific constraints: Low cost sensor, real-time capability, and complexity compatible with on-board hardware. Limited antenna size and costs lead to try to use only mono-polar images.

This paper starts with a description of the test-data, followed by a brief description of the ATR algorithm. Its main purpose is the detection of potential targets and the false alarm rejection: Trees, other vehicles... Next, the results of the ATR are presented and the study focuses on the aspect angle and polarization influence.

2. DATA DESCRIPTION

Two sources of data are used in this paper. The first one comes from MIMEX-PACKAGE 4 and the second one is given by FGAN in MATRIX 2005 context.

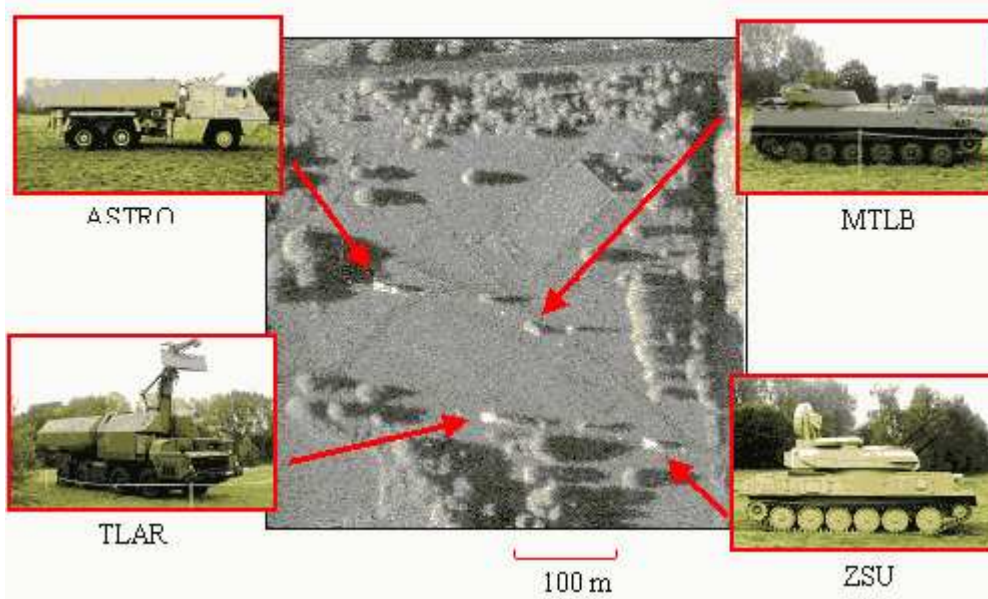
2.1. MIMEX

The image selected from the MIMEX database is an 1100 pixels by 4800 pixels multi-looks image in Ka band with a 50 cm resolution. It contains forests, grass and targets. There are many independent trees, which may be detected as targets and increase the false alarm number. The ground truth is also available. The following picture presents the image and the targets.

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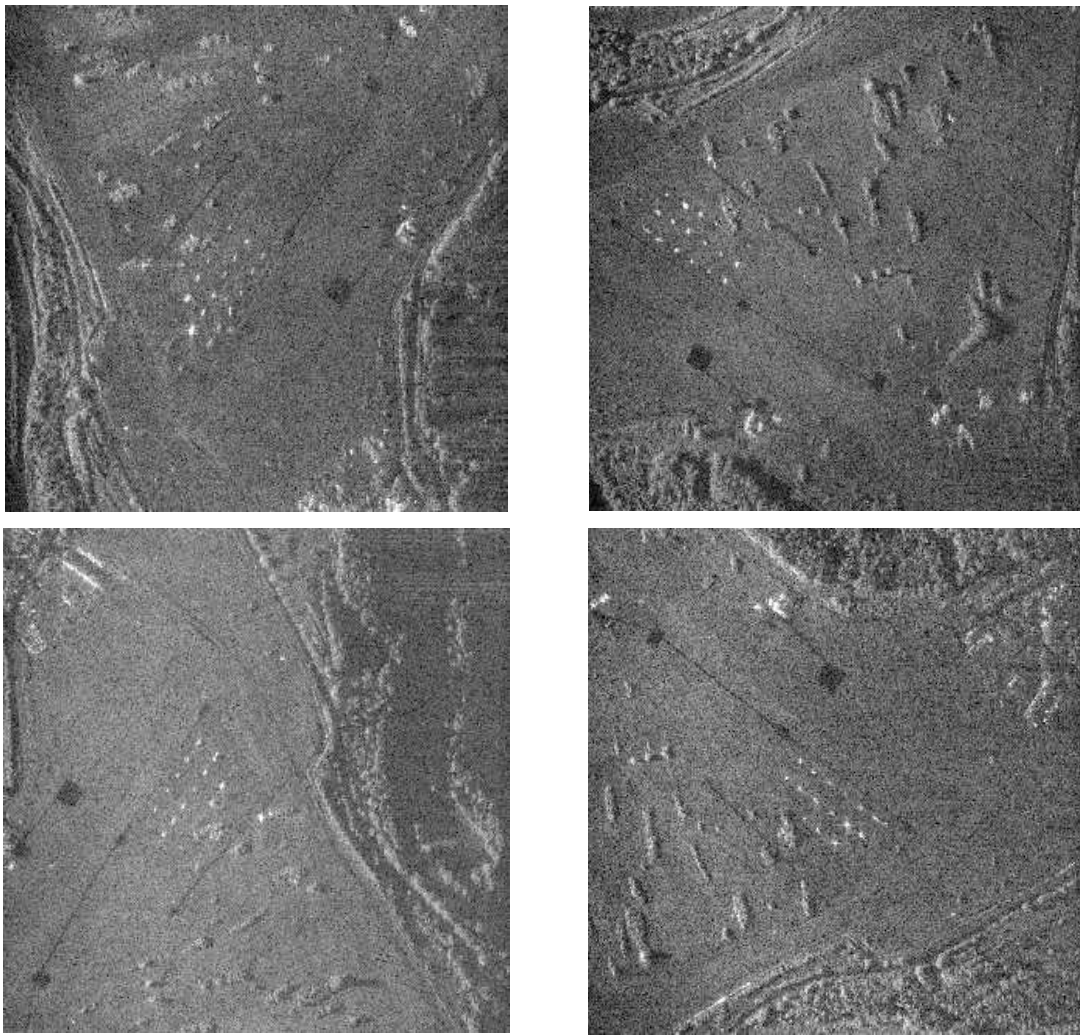


The availability of ground truth and the very good quality of this MIMEX image lead to use it to set up our ATR techniques. Nevertheless, one must keep in mind that this image is produced from a heavy platform with powerful off-line means.

2.2. FGAN

The provided images from the MENPHIS station were acquired with a 20° depression angle and a flight altitude of 400 m. Radar was side looking to the left. The scene contains 17 targets arranged on a regular grid. Other objects present in the target area vicinity are in fact other targets camouflaged and non-camouflaged. Unfortunately, there is no ground truth but the target classes (one T72 tank and one BMP-2 APC). Thus, only a first visual initialization could be used to evaluate our results.

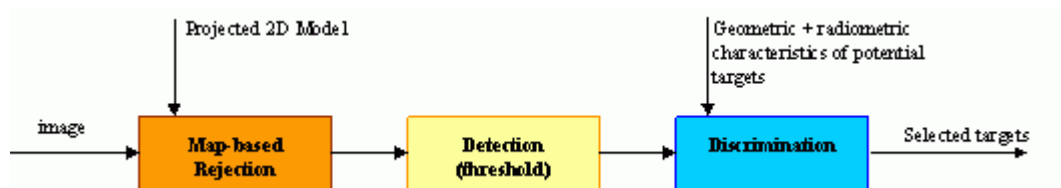
Data with four different headings are provided. The headings are 225° , 45° , 315° and 135° . We have used the multi-polarization SLC data to extract three mono-polar images per heading: The magnitude information for HH, HV, and VV polarization. The image sizes are about 1000 pixels by 2000 pixels. In addition to the targets, the scene contains urban areas, forests, grass and roads. It is important to have these additional elements, which could provide many false alarms, to test our algorithm. The following pictures present a part of the used images in the case of a HH polarization.



The general quality and aspect of these images enables us to consider them as representative of images that could be obtained from air to ground sensors. Thus, they seem to be a good choice for an evaluation of our ATR techniques.

3. METHOD OVERVIEW

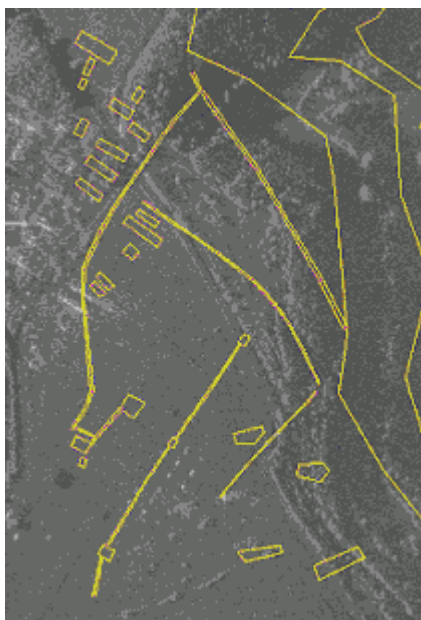
The goal of our method is to have real-time capability and to be easy to initialize in needing just few information supposed to be independent of the aspect angle. The context implies to have limited resolution images. In this way, a complete classification of the scene seems unreachable. Nevertheless, the image quality allows to detect potential targets and to eliminate false alarms. To reduce further the false alarms, the ATR is driven by the area map obtained from the air to ground mission planning. Our method uses then three steps: Mask computation based on refined scene model, detection and classification. The following diagram presents the linking between these steps.



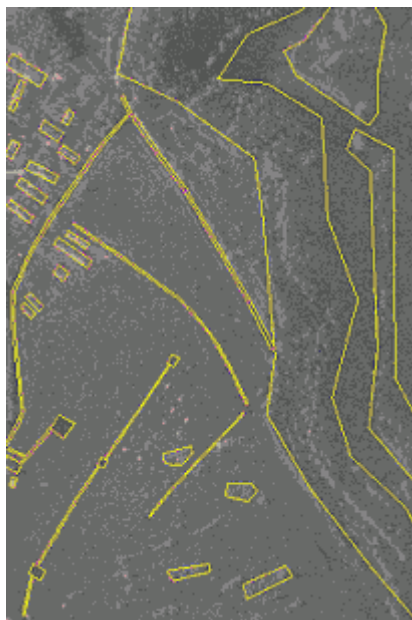
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3.1. MODEL-BASED REJECTION

This first step comes naturally from the terminal guidance process. A scene model is matched to the image content, allowing then to compute detection masks based on terrain content. The following picture presents an example of image matching and cancellation areas.



Projected model based on IMU data



Updated model by image matching



Canceled areas

3.2. DETECTION

The goal of this detection is to select groups of pixels, which are potential targets. The detection is based on the local brightness information. Potential targets in the image have high-level pixels and have a bounded size range. Our detector uses this information to be independent of specific target characteristics. Consequently, there will be many false alarms (model based rejection cannot be exhaustive). This number decreases thanks to the following step. At this stage, a good detection is preferred to a good false alarm rate.

3.3. CLASSIFICATION

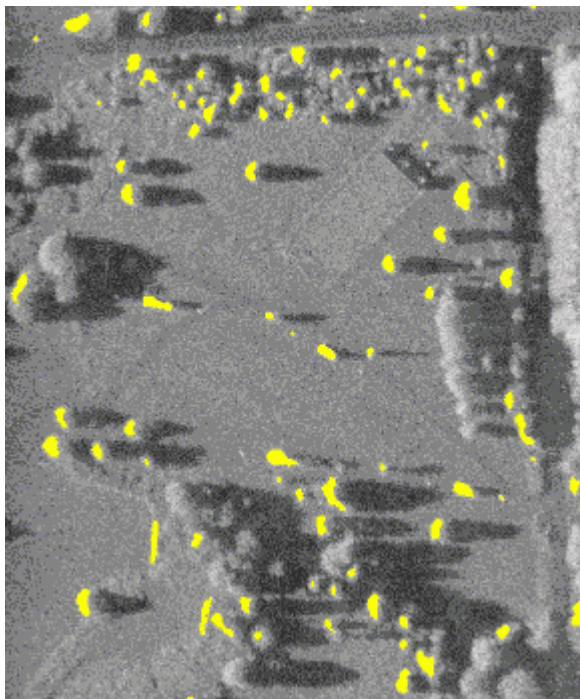
The classification step consists in the matching between characteristics of the detected cluster and the characteristics of the reference. The matching is based on a statistical algorithm. This step allows to reduce the number of false alarms and to select the most probable target. The reference characteristics are calculated on basic geometric properties of the target: Length, width and height. These characteristics correspond in the image to the bounding box size of the detected cluster and to length of the shadow (extracted by another specific detection). Along with these geometric characteristics, statistical features from the radiometry are also used.

4. RESULTS

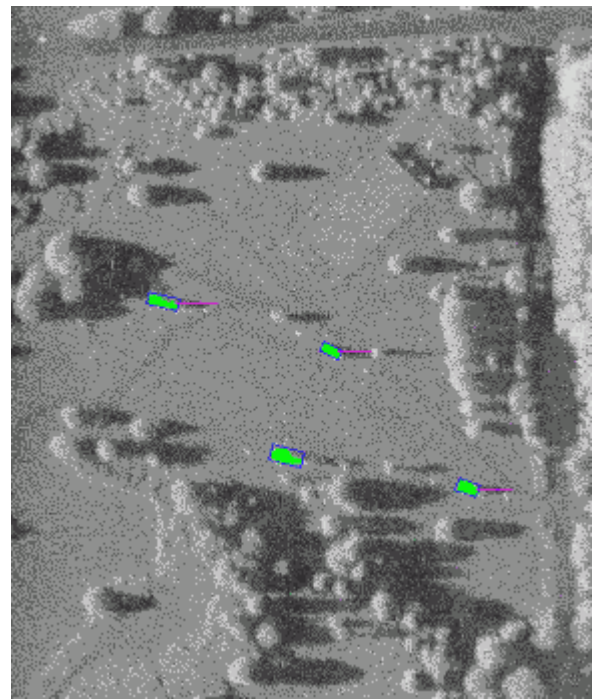
This chapter presents the results of the proposed method applied on MIMEX and FGAN images. The results shown in this part do not use the model-based rejection. In all the presented pictures, detected candidates are yellow, selected targets are green or cyan, the adjusted boxes are blue and the shadows are purple.

4.1. MIMEX DATA

There are four similar targets. The algorithm is initialized with one kind of target. There are many detections because of the great number of trees. However, the classification step successfully eliminates all the false alarms. The two following pictures present the results of these two steps.



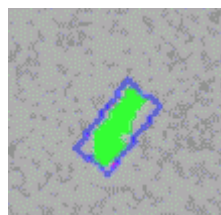
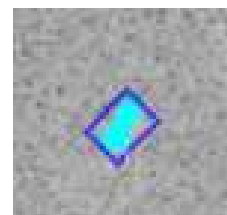
Detection



Classification

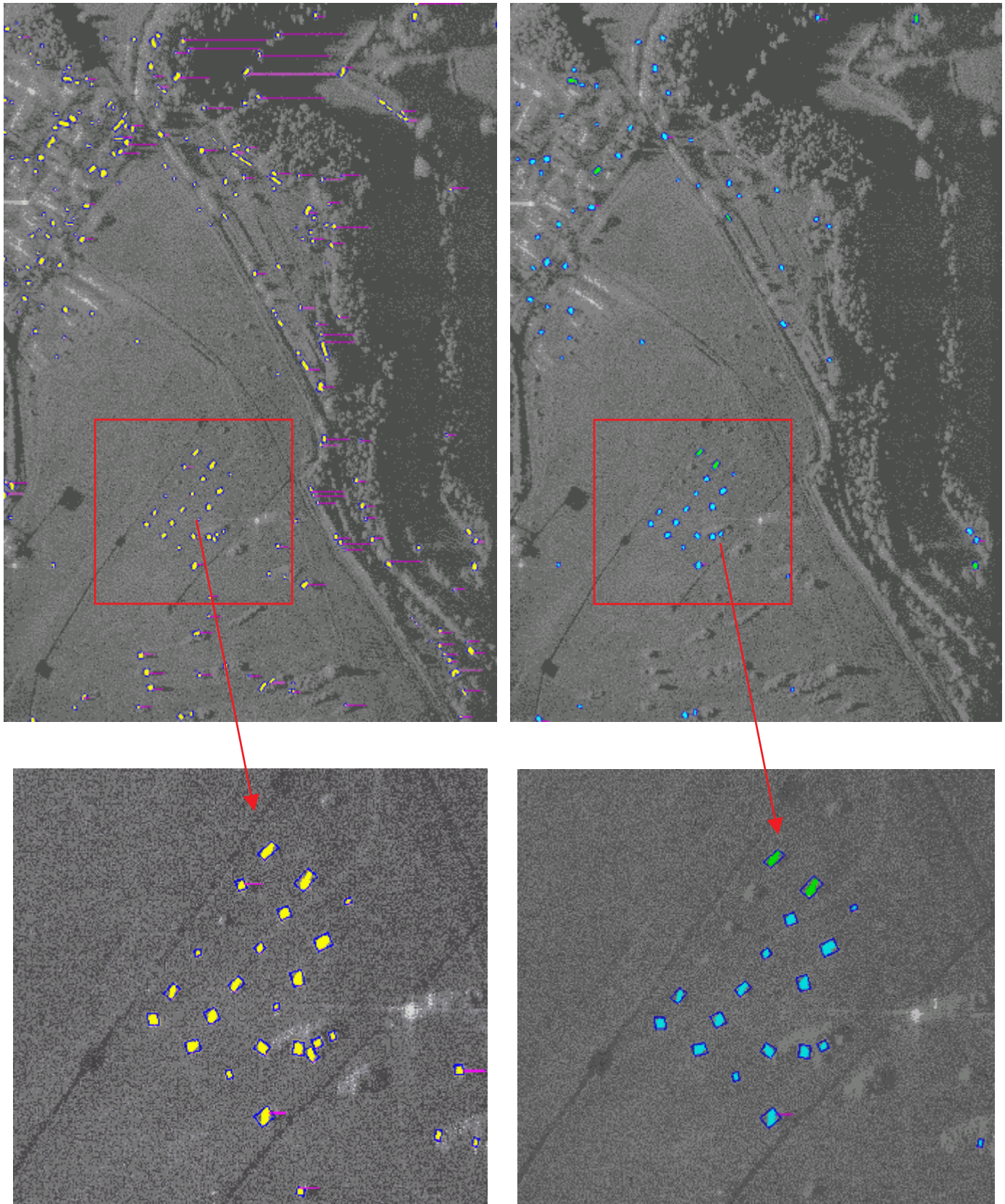
4.2. FGAN

To apply the ATR algorithm on FGAN data, the algorithm is initialized with two types of targets. All the results will use two sets of characteristics based on these two types.


Type A: length / width ~ 2

Type B: length / width ~ 1.5

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The following figures present the results on an HH image (FGAN database, heading 225°).



Detection

Classification

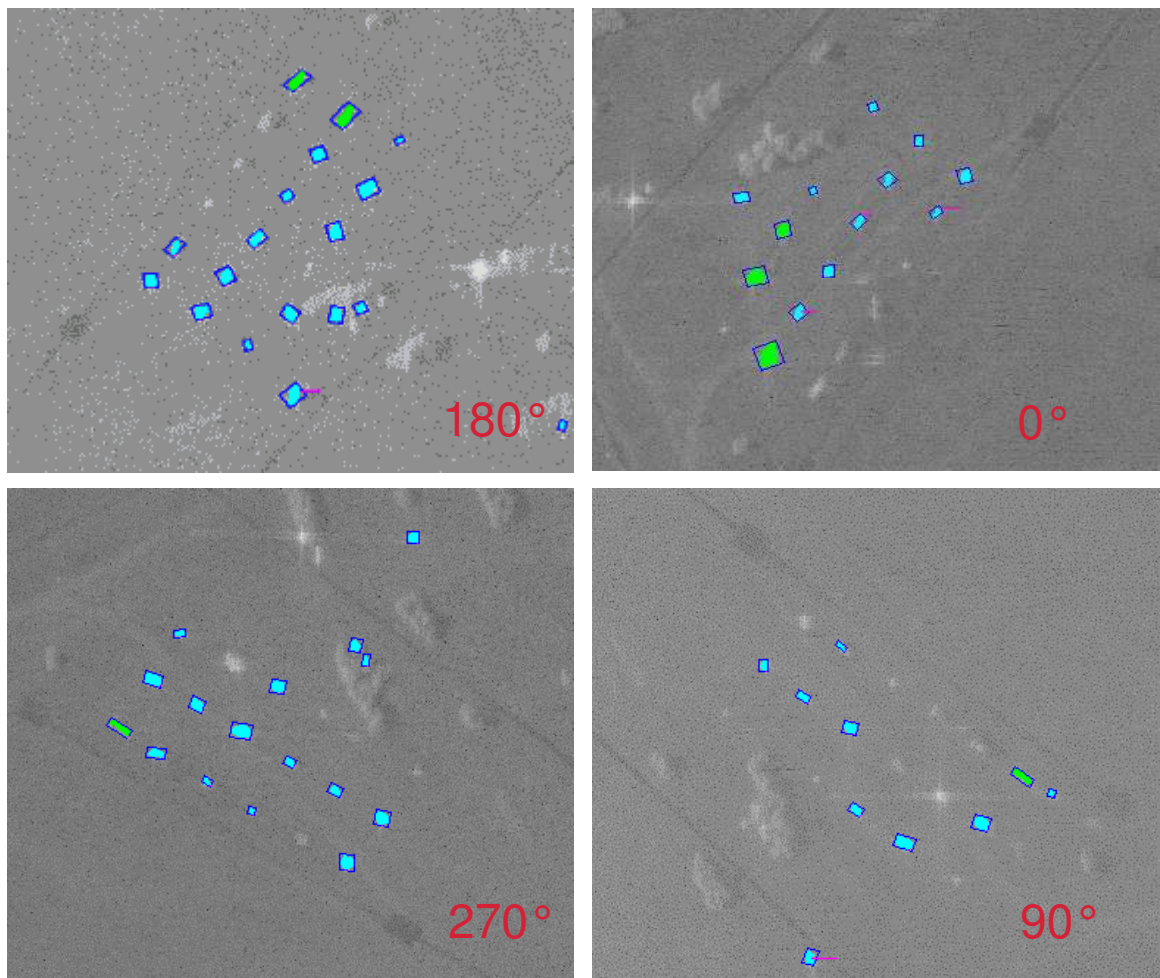
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Detection is quite robust. Most of the false alarms are due to forest and urban areas. We do not notice any false alarm due to the speckle, which is quite important for mono-look images. Nevertheless, as MIMEX results show it, multi-look could improve detection accuracy of group of pixels (shape and size) and the radiometric characteristic estimation. As expected, the classification decreases the number of false alarms. The global performances are good: To have 76 % of detection for the 17 given targets, there are 65 false alarms. However, it is important to notice that this number includes other probable targets which are not labeled such as targets at initialization. What is more, the model-based rejection could handle most of the remaining false alarms.

This false alarm number is higher than the one in MIMEX image because of the difference of image quality. It points out the influence of image quality. A quick analyze of detection step emphasizes that the extracted shape is more accurate in MIMEX images. The next parts presents results with other headings and other polarizations.

4.3. ROBUSTNESS ON ASPECT ANGLE

The analysis of the aspect angle influence on the algorithm performances uses HH polarization. The algorithm settings are chosen to have comparable false alarm rate. The following pictures present the classification results.



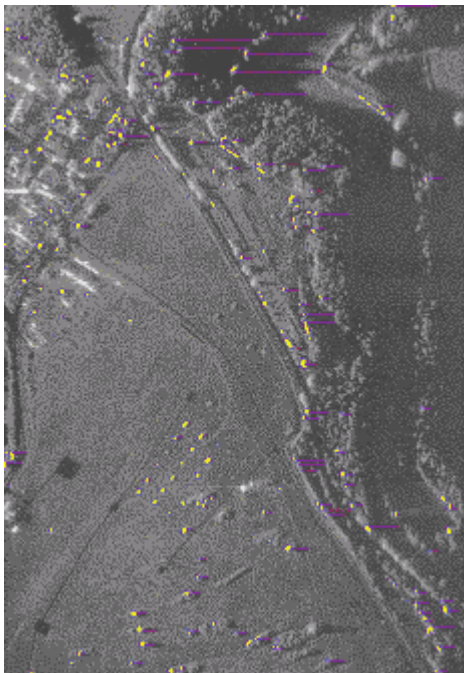
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The fact that the algorithm is more or less robust on the aspect angle depends on the type of target. Image quality for 90° is more difficult (low contrast). The following table presents the capability to select targets. The next step of this study will be to get a description of these targets to analyze the results.

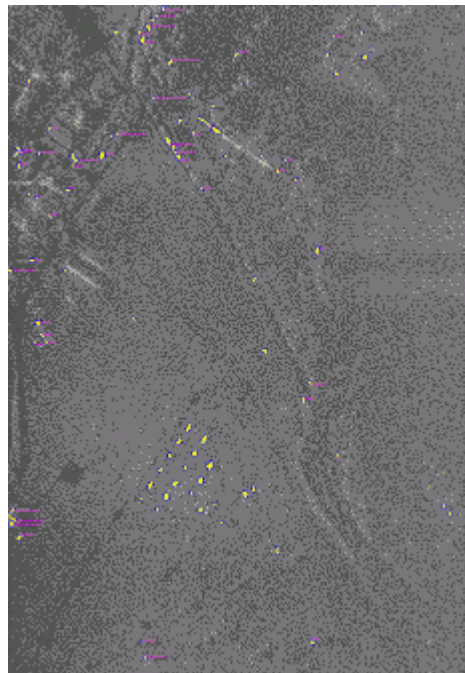
A.A. Target	180	0	270	90
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4.4. INFLUENCE OF POLARIZATION

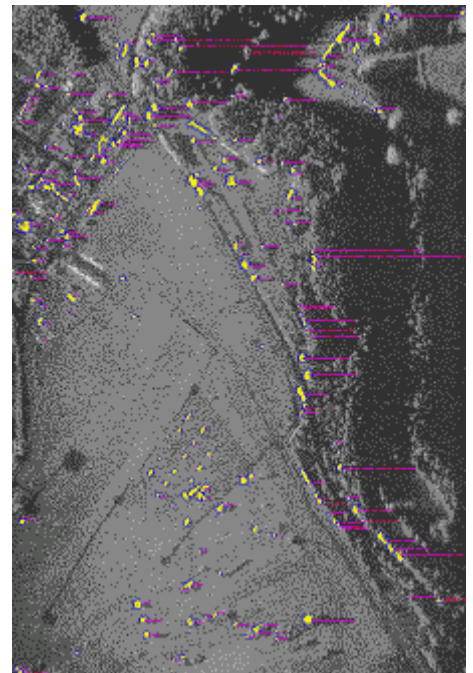
To analyze the polarization influence, the algorithm is characterized with ROC (Receiver Operating Characteristic) figures. First, the following figures present results of detection and classification for a selected setting, which is a compromise between detection rate and false alarm number: The main constraint is to have a detection rate higher than 80 %.



Detection: HH

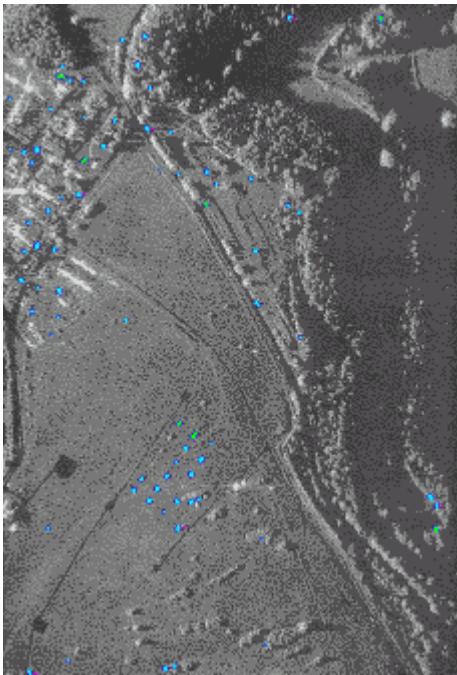


Detection: HV

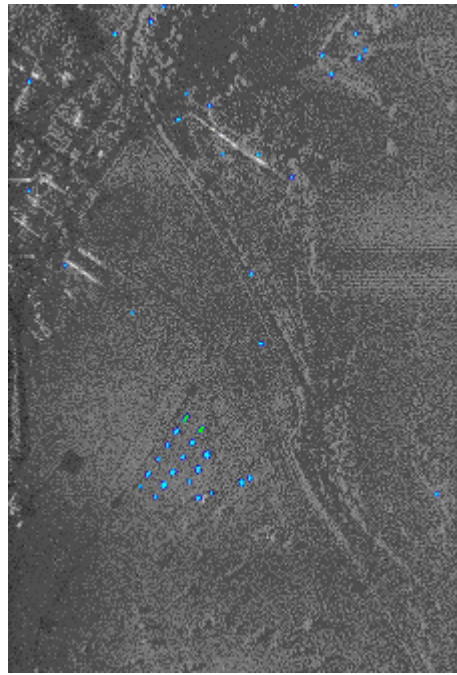


Detection: VV

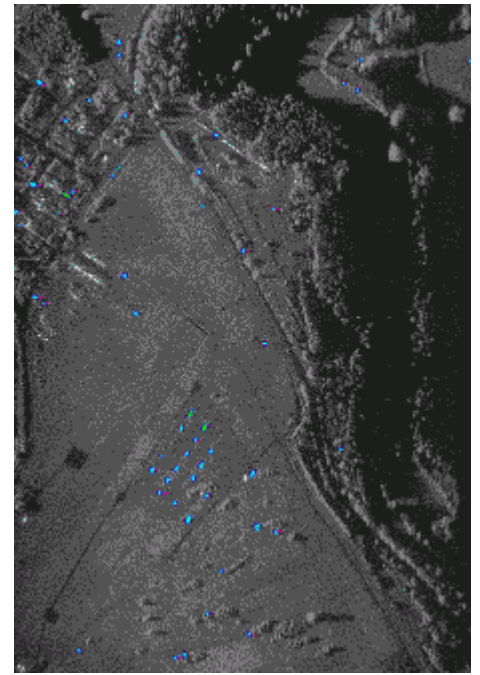
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Classification: HH

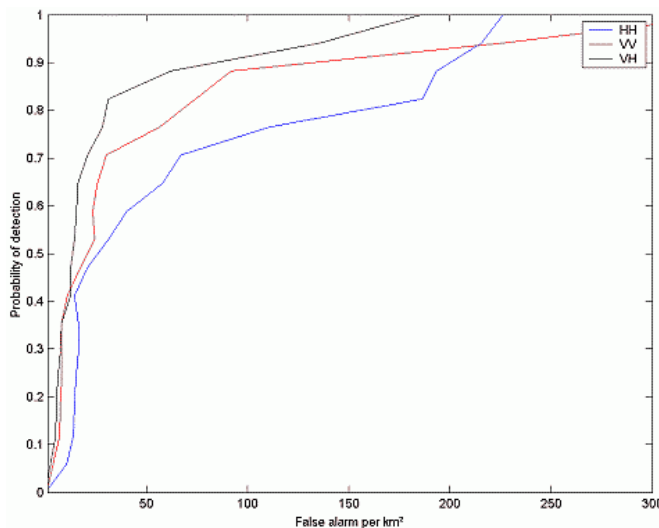


Classification: HV

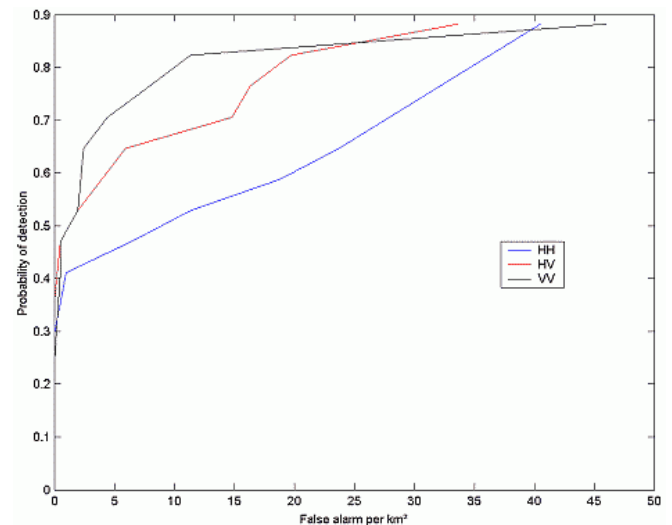


Classification: VV

The ROC figures are:



ROC: Detection



ROC: Classification

These figures present the differences between the polarizations. The detection with HV is better. Indeed, the target reflection is higher and more different than the one of other elements such as trees. It implies that it is easy to detect them with a smaller false alarm number.

With the classification step the difference between HH and VV becomes higher and the difference between HV and VV become smaller. VV has the more information to discriminate target. The best compromise is to detect targets with HV polarization and to discriminate them with VV polarization. However, the low cost context does not allow using both of them. Consequently, if the only task is ATR, HV could be the best choice.

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5. CONCLUSION

A detection and false alarm rejection algorithm has been set-up, taking into account our operational constraints. The first results show a good capability to detect and to select potential targets. The performances are good on MIMEX and FGAN images.

The results on the FGAN database provide cues for polarization selection. From the point of view detection limited to displaceable targets, the HV polarization optimizes the detection capacity, in accordance with the radar theory. The VV polarization still gives good results with better contrasts on the objects of the context.